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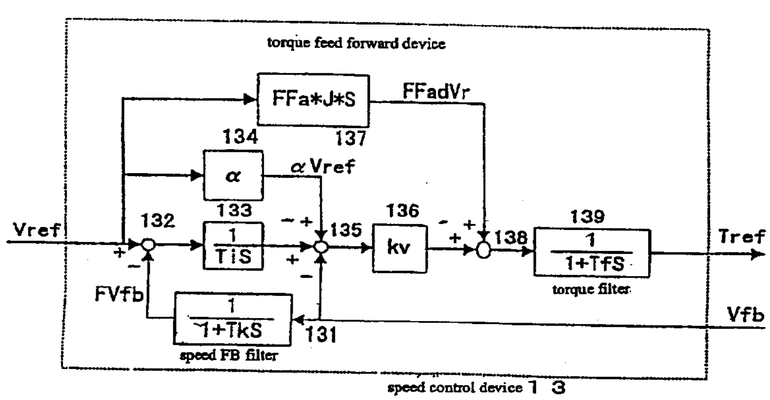
(54) POSITION CONTROLLER

(57) A position controller which controls the position of a motor comprising a position control unit (12) which controls the position of the motor so that the position of the motor may agree with the position command of a command generator (11), a speed control unit (13) which outputs a torque command and controls the speed of the motor so that the speed of the motor may agree with the speed command of the position control unit (12) and a current control unit (14) which controls the current applied to the motor in accordance with the command of the speed control unit (13). The speed control unit (13) has a speed feedback filter (131) by which the speed is applied to a low-pass filter, a subtracter (132) which subtracts the signal of the speed feedback filter (131) from the speed command to obtain a speed deviation, an integrator (133) which integrates the speed deviation with respect to time to obtain an integrated speed deviation value, a multiplier (136) which multiplies the speed command by a coefficient α, an adder/subtracter (135) which adds the signal of the multiplier to the integrated speed deviation value and, further, subtracts the speed from the sum, a multiplier (136) which multiplies the output of the adder/subtracter by a speed loop gain Kv and a torque filter (139) which applies the signal of the multiplier (136) to a low-pass filter.

Fig. 3



EP 0 967 535 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a position controller for motors, robots, machine tools, etc., and in particular to a position controller for which a high speed response is required.

BACKGROUND ART

[0002] As a position controller aiming at a high speed response, for example, a position controller is available, which is provided with a command generator for generating position instructions, a position control unit for controlling a position by inputting a position instruction and the position of a motor being an object to be controlled, and outputting a speed instruction so that they become coincident with each other, a speed control unit to control a speed by inputting a speed instruction and a speed of the motor, and outputting a torque instruction so that they become coincident with each other, and a current control unit for controlling a current on the basis of the inputted torque instruction, and further provided with a subtracter which obtains a speed deviation by subtracting the speed from the speed instruction, an integrator which obtains an integral figure of the speed deviation by time-integrating the speed deviation with a time constant Ti, a multiplier for multiplying the speed instruction by α ($0.0 \leqq \alpha \leqq 1.0$), an adder and subtracter which adds a signal of the multiplier to an integral figure of the speed deviation and at the same time subtracts the speed therefrom, multiplier for multiplying an output of the adder and subtracter speed loop gain, and a torque filter for filtering a signal of the multiplier through a low-pass filter and making it into a new torque instruction.

[0003] However, there is such a problem by which in cases where the speed loop gain is increased or where the time constant is shortened, the control system itself may be likely to vibrate by delay of the torque filter consisting of a low-pass filter secured to suppress vibrations induced by the mechanical system.

DISCLOSURE OF INVENTION

[0004] It is therefore an object of the invention to provide a position controller to solve the problem. A position controller according to the first claim of the invention has a command generator for generating position instructions, a position control unit for controlling a position by inputting a position instruction and the position of a motor being an object to be controlled, and outputting a speed instruction so that they become coincident with each other, a speed control unit for controlling a speed by inputting a speed instruction and a speed of the motor and outputting a torque instruction so that the speed instruction and speed become coincident with each other, and a current control unit for controlling a current on the basis of the torque instruction, wherein the speed control unit is provided with a speed feedback filter which obtains a new speed of a motor by filtering the speed through a low-pass filter, a subtracter which obtains a speed deviation by subtracting the new speed from the speed instruction, an integrator which obtains an integral figure of the speed deviation by time-integrating the speed deviation by a time constant Ti, a multiplier which multiplies the speed instruction by α ($0.0 \leqq \alpha \leqq 1.0$), an adder and subtracter which adds a signal of the multiplier to the integrated figure of the speed deviation and subtracts the speed therefrom, a multiplier which calculates a torque instruction by multiplying the output of the adder and subtracter by a speed loop gain kv, and a torque filter which makes a torque instruction into a new torque instruction by filtering it through a low-pass filter.

[0005] A position controller according to the second claim of the invention is featured in that the position control unit is provided with a speed feed forward device which multiplies the position instruction by a speed feed forward constant FF ($0.0 \leqq FF \leqq 1.0$) after differentiating the position instruction by time, and an adder which obtains a new speed instruction by adding a signal of the speed feed forward device to the speed instruction.

[0006] A position controller according to the third claim of the invention is featured in that the speed control unit is provided with a torque feed forward device which differentiates the speed instruction by time and makes it (motor inertia + load inertia) -fold, and multiplies it by the torque feed forward constant FFa ($0 \leqq FF \leqq 1$), and an adder which obtains a new torque instruction by adding a signal of the torque feed forward device to the signal of the multiplier.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a block diagram of a motor control system to which the present invention is applied;

FIG. 2 is a view showing the details of a position control unit in FIG. 1;

FIG. 3 is a view showing the details of a speed control unit in FIG.1; and

FIGS. 4 are views showing examples of actions where a one-axis roller slider is driven by using the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0008] FIG. 1 is a block diagram of a motor controlling system to which the present invention is applied. A command generator 11 outputs a position instruction Pref.

The position control unit 12 carries out position control by inputting the position instruction Pref and a position Pfb of a motor 15, which is detected by a detector 16, so that the position instruction Pref becomes coincident with the position Pfb, and outputs a speed instruction Vref. A speed control unit 13 carries out speed control by inputting the speed instruction Vref and a speed Vfb of the motor, which is obtained by a differentiator 17 taking a differential of the position Pfb, so that the speed instruction Vref and speed Vfb become coincident with each other, and outputs a torque instruction. A current control unit 14 outputs a current in response to a torque instruction Tref by inputting the torque instruction Tref and drives the motor 15.

[0009] And, the speed of the motor 15 is controlled by a speed control loop consisting of the speed control unit 13, current control unit 14, motor 15, detector 16 and differentiator 17, so that the motor 15 rotates at a speed rate responsive to a speed instruction Vref of the position control unit 12. Further, by a position control loop in which a position control unit 12 is added to the speed control loop, the position of the motor 15 is controlled so that the rotation position of the motor 15 becomes responsive to a position instruction Pref of the command generator 11.

[0010] FIG. 2 is a view showing details of the position control unit 12. The position control unit 12 consists of a subtracter 121 which obtains a position deviation Pe by inputting the position instruction Pref and motor position Pfb and subtracting the motor position Pfb from the position instruction Pref, a multiplier 122 which outputs the speed instruction Vref by making the position deviation Pe position loop gain Kp fold, a speed feed forward device 123 which obtains a speed feed forward signal FFdPr by differentiating the position instruction Pref by time and multiplying it by a speed feed forward constant FF ($0 \leqq FF \leqq 1.0$), and an adder 124 which adds a speed feed forward signal FFdPr to the speed instruction Vref and makes a new speed instruction Vref. Thereby, the the position control unit 12 outputs the speed instruction Vref to the speed control unit 13.

[0011] FIG. 3 is a view showing details of the speed control unit 13. The speed control unit 13 consists of a speed FB filter 131 which obtains a speed FVfb by inputting a speed instruction Vref and a speed Vfb, and filtering the speed Vfb through a low pass filter, a subtracter 132 which obtains a speed deviation Ve by subtracting the speed FVfb from the speed instruction Vref, an integrator 133 which obtains an integrated figure SVe of the speed deviation by time-integrating the speed deviation Ve by a time constant Ti, a multiplier 134 which obtains a proportional signal α Vref by multiplying the speed instruction Vref by α ($0.0 \leqq \alpha \leqq 1.0$), an adder/subtracter 135 which adds the proportional signal α Vref to the integrated figure SVe of the speed deviation and subtracts the speed Vfb therefrom, a multiplier 136 which calculates a torque instruction Tref by multiplying an output of the adder/subtracter by a speed loop gain Kv, a torque feed forward device 137 which differentiates the speed instruction Vref by time, makes J J-fold as the sum of motor inertia and load inertia, multiplies it by the torque feed forward constant FFa ($0 \leqq$ FFa $\leqq 1.0$), and outputs a torque feed forward signal FFadVr, an adder 138 which makes a new torque instruction Tref by adding the torque feed forward signal FFadVr to the torque instruction Tref, and a torque filter 139 which creates a new torque instruction Tref by filtering the torque instruction Tref through a low pass filter. Thereby, the speed control unit 13 outputs a torque instruction Tref to the current control unit 14.

[0012] FIGS. 4 are views showing examples of actions where a one-axis roller slider is driven by using the present invention, wherein, as shown in a conventional example, (a) shows a state wherein a torque filter is employed in order to suppress vibrations, P (proportional) control is adopted for position control, and 1-P (integration proportion) control ($\alpha = 0$) is adopted for speed control. In addition, speed feed forward and torque feed forward are not employed (FF = FFa - 0), and (b) shows a state where a response according to the present invention is employed which is such that a speed FB filter is added to the conventional example. The control parameters of the present invention are the same as those in the conventional example, wherein the position loop gain is Kp = 200rad/s, speed loop gain is Kv = 200Hz, time constant of speed loop integration is Ti = 1.56ms, and torque filter is Tf = 0.4ms. However, the preferred embodiment of the invention is provided with a speed FB filter, and the time constant becomes Tk = 0.4ms. As has been made clear from the drawings, overshoot arises when positioning in the conventional example. Kv may be increased or Ti may be shortened in order to eliminate the overshoot. However, Kv and/or Ti cannot be adjusted anymore because vibrations occur. In addition, although the overshoot can be eliminated by lowering Kp, the positioning time may be lengthened. On the other hand, in the preferred embodiment of the invention, a high speed positioning can be achieved without making any overshoot. Further, in the drawing, Pref indicates a position instruction, Pfb indicates a motor position, Pe indicates a position deviation, Pe' indicates enlargement of Pe, and Tref indicates a torque instruction.

INDUSTRIAL APPLICABILITY

[0013] As described above, according to the invention, since the speed control unit is provided with a speed FB filter, the control system itself does not vibrate even though the speed loop gain is increased or the time constant is shortened, wherein a quick reach at an objective position can be achieved. Therefore, it is possible to provide a position controller which has high performance and useful applicability.

Claims

1. A position controller for controlling a motor position, comprising:

   a command generator for generating a position instruction;
   a position control unit for controlling a position by inputting a position instruction and a motor position being an object to be controlled and outputting a speed instruction so that they become coincident with each other;
   a speed control unit for controlling a speed by inputting a speed instruction and a speed of said motor and outputting a torque instruction so that they become coincident with each other; and
   a current control unit for controlling a current on the basis of the torque instruction;
   wherein said speed control unit comprises;

      a speed feedback filter which obtains a new speed of a motor by filtering the speed through a low-pass filter;
      a subtracter which obtains a speed deviation by subtracting the new speed from the speed instruction;
      an integrator which obtains an integrated figure of the speed deviation by time-integrating the speed deviation by a time constant Ti;
      a multiplier for multiplying the speed instruction by a coefficient α ($0.0 \leqq \alpha \leqq 1.0$);
      an adder and subtracter which adds an integrated figure of the speed deviation to a signal of the multiplier and subtracts the speed therefrom;
      a multiplier for multiplying the output of the adder/subtracter by a speed loop gain Kv and for calculating a torque instruction; and
      a torque filter for making a new torque instruction by filtering the torque instruction through a low-pass filter.

2. A position controller as set forth in Claim 1, wherein said position control unit comprises;

   a speed feed forward device for differentiating a position instruction by time and multiplying it by a speed feed forward constant FF ($0.0 \leqq FF \leqq 1.0$); and

   an adder which obtains a new speed instruction by adding a signal of the speed feed forward device to the speed instruction.

3. A position controller as set forth in Claim 2, wherein said speed control unit comprises;

   a torque feed forward device for differentiating the speed instruction by time, making it (motor inertia + load inertia) -fold, and multiplying it by a torque feed forward constant FFa (($0 \leqq FFa \leqq 1$); and

   an adder which obtains a new torque instruction by adding a signal of the torque feed forward device to the signal of said multiplier.

Fig. 1

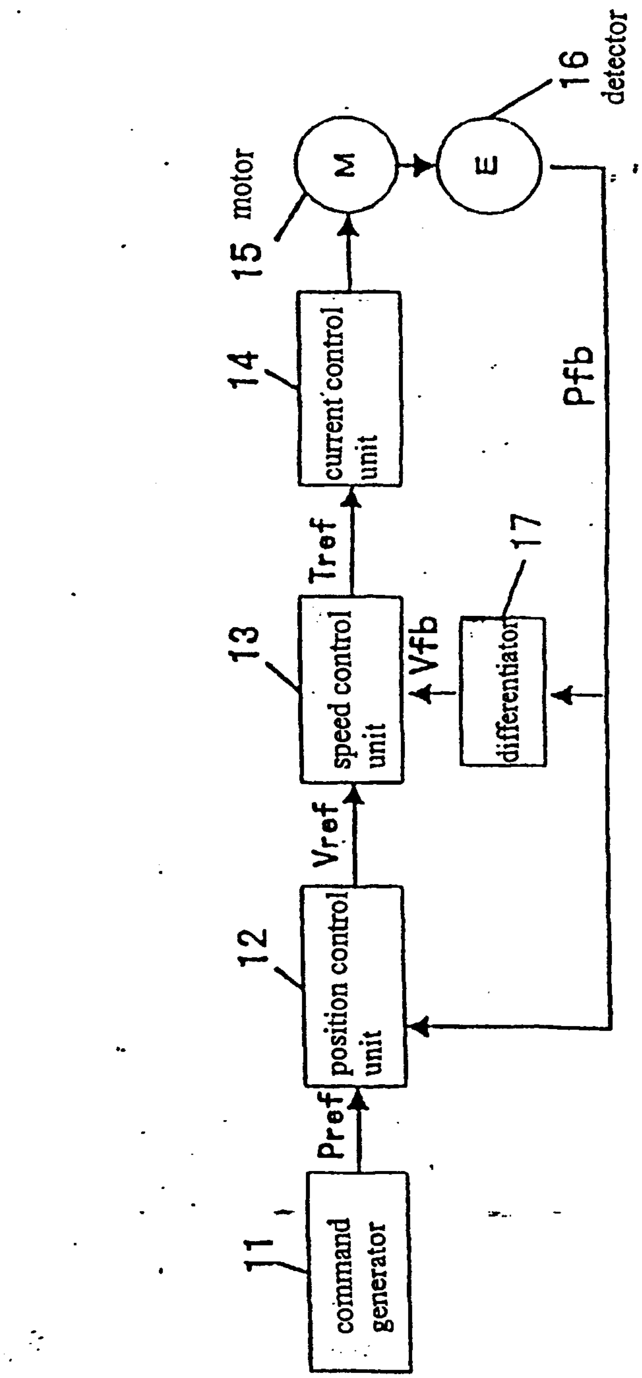

11
command generator
Pref
12
position control unit
Vref
13
speed control unit
Tref
14
current control unit
15 motor
M
E
16
detector
Pfb
17
differentiator
Vfb

Fig. 2

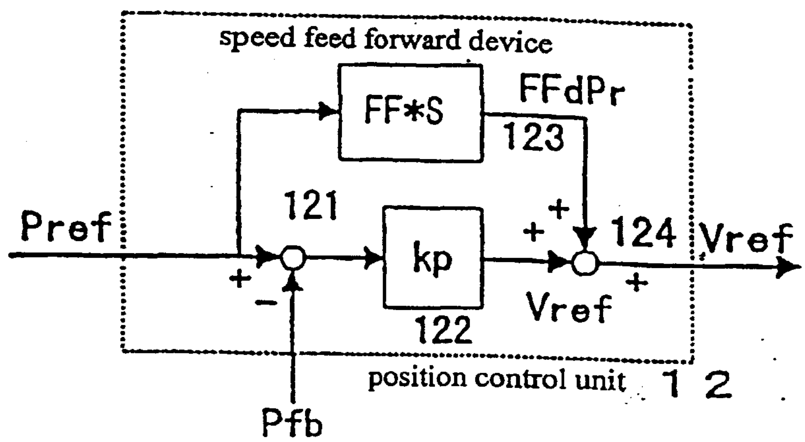
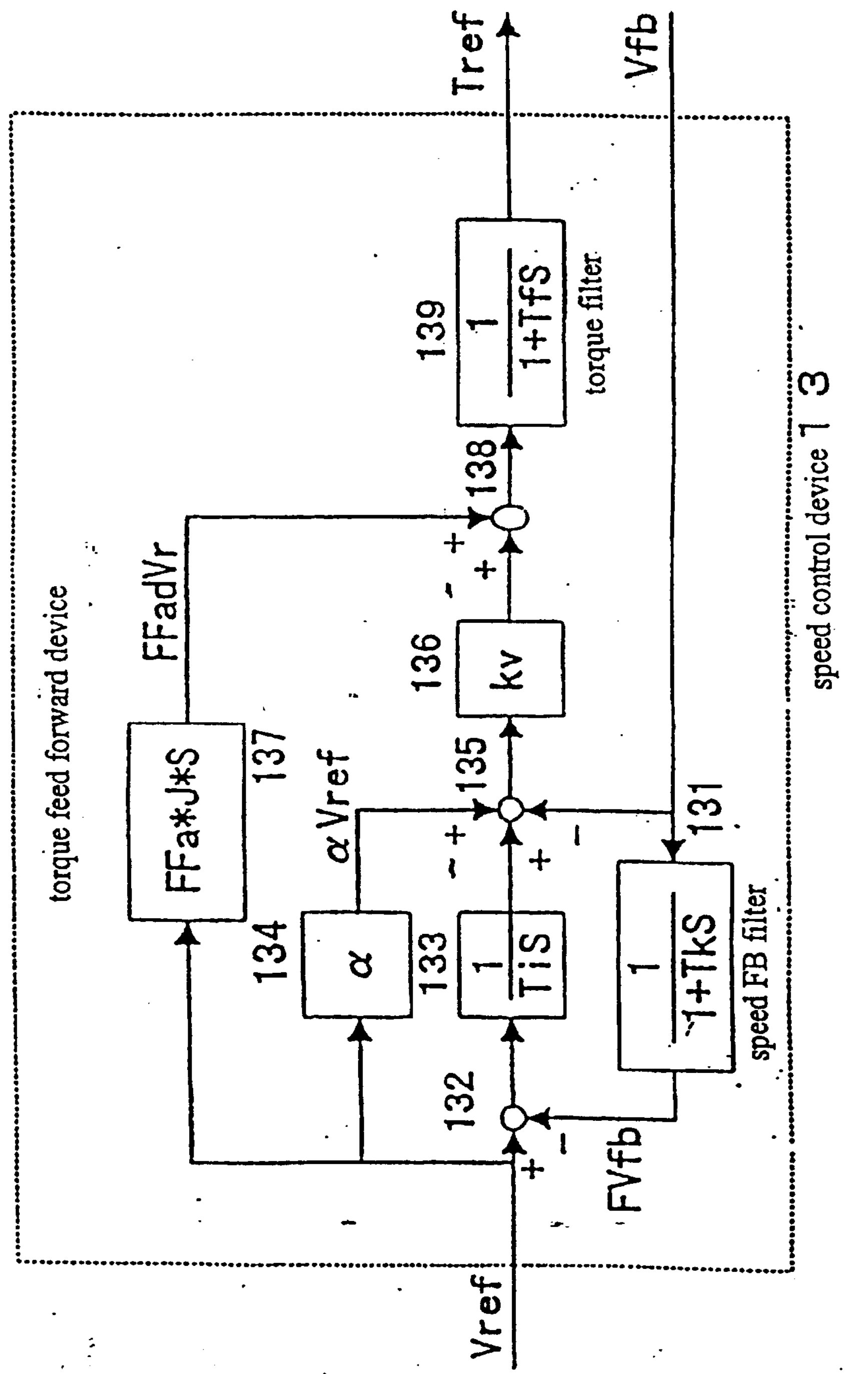

speed feed forward device
FF*S
FFdPr
123
Pref
121
kp
124
Vref
+
+
+
−
+
+
Vref
122
position control unit 12
Pfb

Fig. 3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Vfb
139
1
1+TfS
torque filter
138
FFadVr
torque feed forward device
136
kv
137
FFa*J*S
αVref
135
131
134
α
133
1
TiS
1
1+TkS
speed FB filter
132
FVfb
Vref
speed control device 13

Fig. 4a

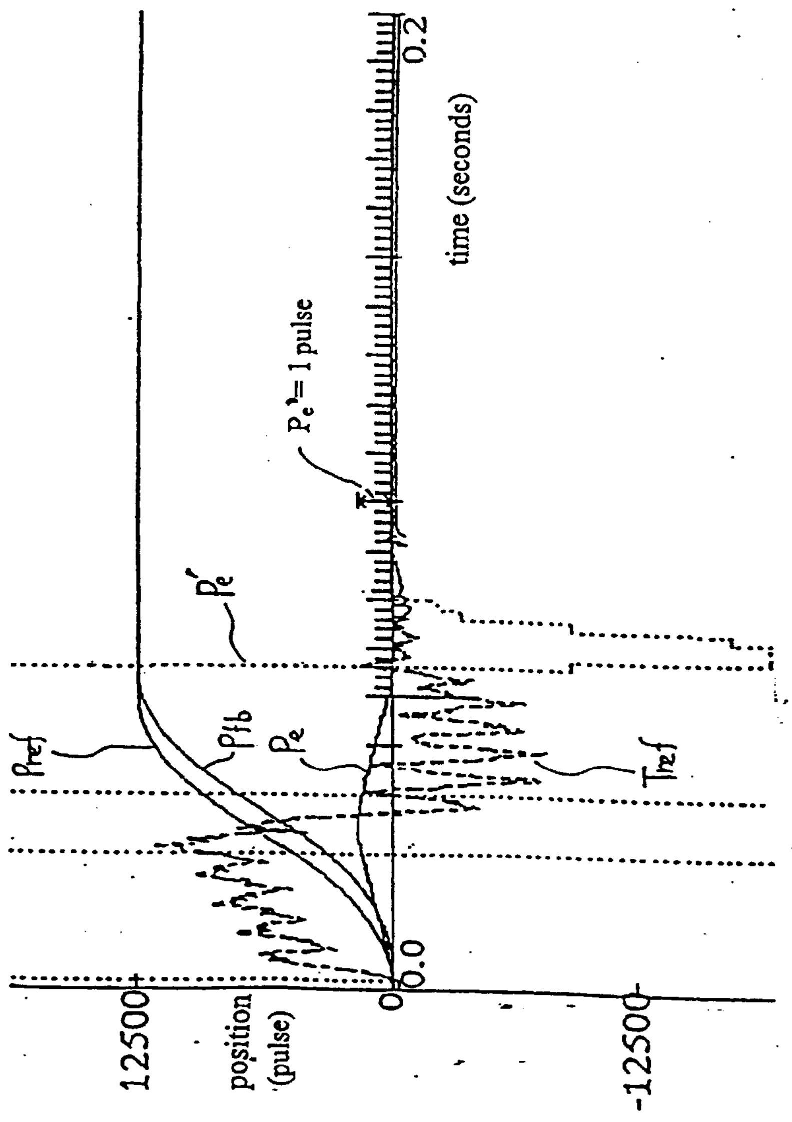
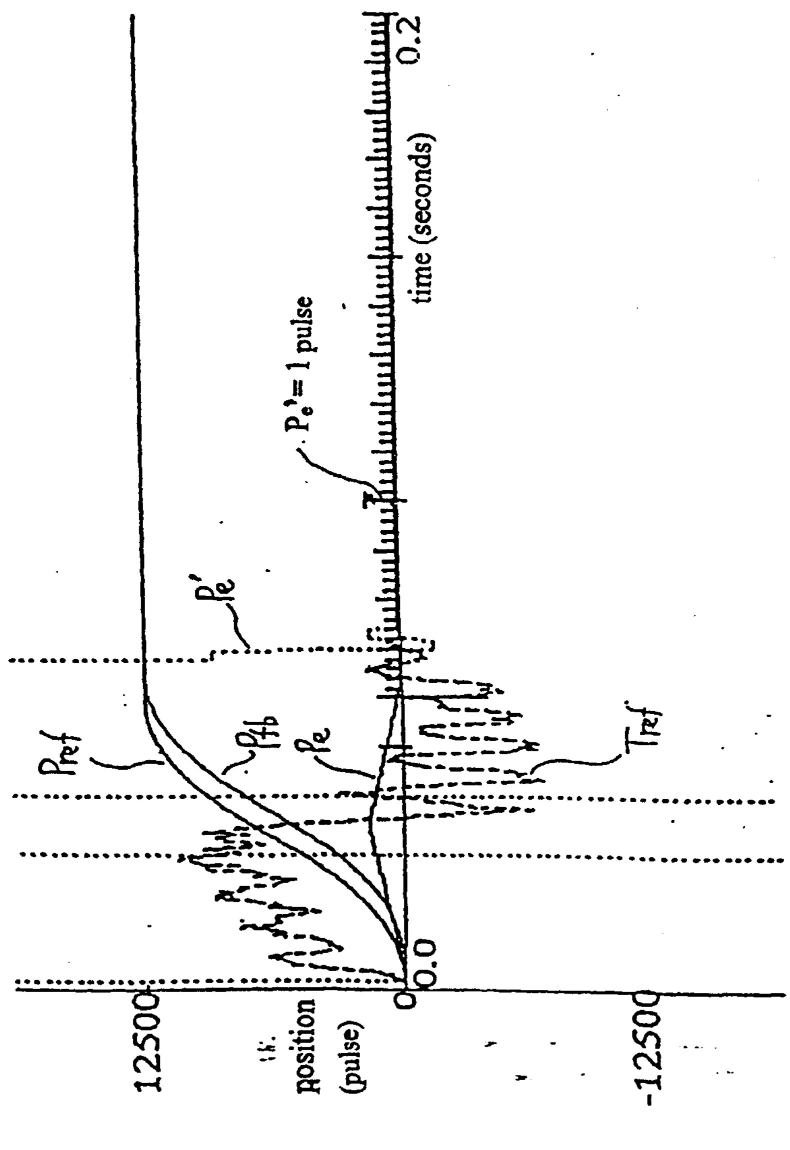

12500
position
(pulse)
0
-12500
0.0
0.2
time (seconds)
Pref
Pfb
Pe
Pe'
Tref
Pe' = 1 pulse

Fig. 4b


12500
0
-12500
position
(pulse)
0.0
0.2
time (seconds)
P'e = 1 pulse
Pref
Pfb
Pe
P'e
Tref

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/03147

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 G05D3/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^6 G05D3/12, 3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1926 - 1996
Kokai Jitsuyo Shinan Koho 1971 - 1996

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 3-78802, A (Yaskawa Electric Corp.), April 4, 1991 (04. 04. 91)(Family: none)	1 - 3
A	JP, 7-164282, A (Yaskawa Electric Corp.), June 27, 1995 (27. 06. 95)(Family: none)	1 - 3
A	JP, 4-271412, A (Toyoda Machine Works, Ltd.), September 28, 1992 (28. 09. 92)(Family: none)	1 - 3
A	JP, 4-213701, A (Canon Inc.), August 4, 1992 (04. 08. 92)(Family: none)	1 - 3
A	JP, 4-64898, A (Mitsubishi Heavy Industries, Ltd.), February 28, 1992 (28. 02. 92)(Family: none)	1 - 3

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
January 8, 1998 (08. 01. 98)	January 20, 1998 (20. 01. 98)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)